DOCUMENT RESUME

ED 152 239 IR 005 629

AUTHOR Call-Himwich, Eileen; Steinberg, Esther R.
TITLE Myth and Reality: Essential Decisions in Computer-Based Instructional Design.
INSTITUTION Illinois Univ., Urbana. Computer-Based Education Lab.
SPONS AGENCY Advanced Research Projects Agency (DOD), Washington, D.C.
REPORT NO MTC-R-18
PUB DATE Nov 77
CONTRACT DAHC-15-73-C-0077
NOTE 42p.

EDRS PRICE MF-$0.83 HC-$2.06 Plus Postage.
DESCRIPTORS *Computer Assisted Instruction; *Decision Making; Display Systems; Evaluation Methods; *Guidelines; Guides; *Instructional Design; Media Selection; Universities

ABSTRACT

This guide discusses five common CAI author misconceptions and their consequences. Working backward in each instance to show how the difficulty might better have been approached at the onset, it attempts to map out essential decision points in lesson development. The decision points identified cover (1) choosing the best medium for the lesson, (2) deciding on the goals of the lesson, (3) determining the approach the lesson will take, (4) deciding how to question the student, (5) displaying the material, (6) allowing for all student responses, (7) replying to student responses, (8) informing students about their progress, and (9) evaluating the lesson. (DAG)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

ED152239

U S DEPARTMENT OF HEALTH,
EDUCATION & WELFARE
NATIONAL INSTITUTE OF
EDUCATION

THIS DOCUMENT HAS BEEN REPRODUCED EXACTLY AS RECEIVED FROM THE PERSON OR ORGANIZATION ORIGINATING IT. POINTS OF VIEW OR OPINIONS STATED DO NOT NECESSARILY REPRESENT OFFICIAL NATIONAL INSTITUTE OF EDUCATION POSITION OR POLICY

MYTH AND REALITY:

Essential Decisions in Computer-Based Instructional Design

(MTC Report Number 18)

Eileen Call-Himwich
Esther R. Steinberg

COMPUTER-BASED EDUCATION RESEARCH LABORATORY
UNIVERSITY OF ILLINOIS, Urbana-Champaign

IR005629

Copyright © 1977 by the Board of Trustees
of the University of Illinois

All rights reserved. No part of this book may be reproduced in any form or by any means without permission in writing from the author.

This research was supported in part by the Advanced Research Projects Agency of the Department of Defense under U.S. Army Contract DAHC-15-73-C-0077.

ACKNOWLEDGMENTS

We would like to thank the members of the MTC and PEER groups who read and commented on this manual. Special thanks also to Elaine Avner for her editorial and moral support and Julie Garrard for typing parts of the manuscript.

TABLE OF CONTENTS

INTRODUCTION. 1

MYTH: IF YOU KNOW HOW TO TEACH, YOU KNOW CAI. 3
Decide Why CAI Is The Best Medium For This Lesson . . . 9

MYTH: A NEW AUTHOR CAN WRITE A LESSON WITHOUT PLANNING. . 10
Decide On The Goals Of The Lesson 13
Decide How You Are Going To Measure Student Performance 14

MYTH: PRESENTING IS TEACHING. 16
Decide What Approach The Lesson Will Take 17
Decide How You Will Question The Student. 20
Decide How To Display The Material. 21

MYTH: THE STUDENT WILL RESPOND THE WAY YOU ANTICIPATE . . 23
Decide How To Allow For All Student Responses 26
Decide How To Reply To Student Responses. 27
Decide How To Let Students Know How They're Doing . . . 29

MYTH: LESSON DEVELOPMENT IS A ONE-SHOT EFFORT 30
Decide How To Evaluate Your Lesson. 32

SUMMARY CHECKLIST 35
REFERENCES. 37

INTRODUCTION

Most "how-to" guides start from the beginning and work forward. This one works backward. It starts with a number of common CAI author "myths" (misconceptions) and their grizzly consequences, then works backward to how the matter might better have been approached in the first place. For this reason, this guide is not so much an attempt to instruct as to forewarn.

Part of the problem with being a beginner at anything is the fact that you don't always know what questions to ask or recognize the times when there are decisions to be made. Thus, our intention here is not only to unearth some misconceptions, but to map out essential decision points in lesson development. We don't claim that these are all the decisions you will ever need to make, but dealing at minimum with these decisions alone should help you write effective lessons. We also don't claim (or intend) that this will provide all the instruction you need for coping with these decisions. Our main intent is to present ways to think about each of the topics presented.

As you go through each section, bear in mind that although individual topics may fall under only one heading, this is not a good reflection of the real-life development process. Most topics spill over into others. One aspect of writing this sort of guide is a persistent feeling of always overlapping. Starting on one topic, we inevitably found ourselves saying, "Well, yes but you can't really talk about X without also talking about Y." And on it would go. So if you begin to get the feeling you've heard this all before, you probably have.

One final comment: as unbelievable as it may seem, all the anecdotes related here are true. They come from a variety of training and educational settings. As well-intentioned as authors are, anyone can fall prey to these pitfalls.

MYTH: IF YOU KNOW HOW TO TEACH, YOU KNOW CAI.

It is 3:30 in the afternoon. For the last half hour or so the instructor and the 32 students in classroom B of the Paramedical Training Center have been continuing a discussion on capillary fluid flow that began at their last session. Congregated in the farthest few seats of the first and second rows are "the brains" of the class. They understand capillary fluid dynamics perfectly. Indeed, they understood it perfectly when they came to class. As the discussion wears on, they become increasingly bored and irritated at the thought that they have to sit through seemingly interminable repetitions of the same points. They slouch in their seats, doodling in their notebooks or staring daydreamily out the windows.

In the back of the room are the slowest students. They are so thoroughly confused they don't even know what questions to ask. The most they can manage is a disheartered, "I don't get it." They are acutely aware that they are the only people in the room who aren't following the discussion. Mainly they feel "stupid"--so much so that they won't take the risk of asking what they fear would be a "dumb" question. They slouch in their seats, doodling in their notebooks, or staring discouragedly out the windows.

Most of the students have been concentrating and following the spirit if not the letter of the discussion. Their comprehension ebbs and flows throughout the session like a music box running down and being rewound again. Each feels s/he understands certain elements, but how the components fit together into a whole is still a little murky in most of their minds. Capt. Stephens, the instructor, is going over a problem on the board for the third time. She is racking her mind to think of yet another way to restate the same concept. She also knows, however, that she can't afford to

spend much more time on this topic. She has to cover capillary fluid flow before the semester is over. A number of students' hands are up and Capt. Stephens calls on one saying, "Ok, we only have time for one more question."

"I still don't understand how you can <u>add</u> pressure and come out with a negative pressure."

A few hands go down, and students nod in shared bewilderment.

"Ok, Sgt. Jensen," Capt. Stephens asks, "what will happen if we increase the ambient pressure in this case to..."

As she's talking Sgt. Slack is glad she didn't ask him. He doesn't know the answer. Neither, as it turns out does Sgt. Jensen, but Jensen comes up with an alternative Slack would never have thought of. Capt. Stephens analyzes <u>why</u> it's wrong, and in doing so clarifies the point for a number of other students.

After finishing her explanation, Capt. Stephens turns and scans the students' faces. Only a couple of those who posed the original question still look puzzled.

"Does that make more sense now?"

Enough students nod so that Capt. Stephens feels the class is ready to move on. She's aware that a number of students are being left behind, but this topic has already taken more time than she had anticipated, and the end of the semester is nearing.

"Ok, do the remainder of the problems to be handed in the next time we meet. Anyone who's still confused can talk to me after class. Now in the time that's left I want to get started on..."

In a small lecture room hundreds of miles away an instructor is delivering his 28th annual lecture on the workings of the fuel injection system. Occasionally he looks up for a cursory scrutiny of the students' faces. A couple of students are asleep in the back, but most are diligently

scribbling down his every word. He wonders whether he's going too fast or too slow or just right. He wonders whether they understand the mysteries he's laying forth. He wonders what's in the minds behind those expressionless faces looking back at him.

If you're a former instructor, you've probably had lots of experience with students in a classroom situation. If you haven't taught, you've still had lots of experience as a student yourself. Either way you're well acquainted with various classroom situations. When working with something new and unfamiliar it's only natural to try to draw on whatever intuition or experience you do have. There's the rub. There are substantial and important differences between CAI and any other educational medium. Many CAI authors (both new and experienced!) feel most comfortable "translating" their understanding of the conditions of one medium into another, especially if they're pressured by time constraints. That seems reasonable, but unfortunately most classroom technique doesn't "translate" very well onto a computer. For example, we have encountered a number of former lecturers who, after being enchanted by the potential of the computer, decided to convert much of their material to CAI. Unfortunately, their lessons turned out to be transcriptions of their lectures. That was what they knew best, so that's what they did.

Let's look again at the preceding scenarios and enumerate some of the characteristics of the classroom and lecture approaches.

The most obvious characteristic of classroom instruction is that it's group paced. Instruction moves along at the rate at which the majority of the students can keep pace.

This naturally means that a fair amount of the brighter students' time is wasted in sitting through repetitions of things they already understand. It also means that slower students are often left behind, not only because they don't catch on to the material as quickly but also because they're often inhibited about asking questions and "revealing" their ignorance. They need specific, individual help but are often embarassed to ask for it. However, the instructor is able to look around the room and visually assess students' reactions to what's going on -- to catch any furrowed looks of perplexity, or enthusiastic nods of recognition.

In addition, the instructor is often under pressure to cover a predetermined amount of material in a certain length of time, and is thus compelled to push the group harder than may be wise.

An advantage of classroom instruction is information from other students' mistakes. Naturally, wrong answers are wrong for a variety of reasons. One student may give a wrong response another would never have thought of, but the feedback on why it's wrong can be useful to both of them.

Finally, in a classroom situation, most of the necessary practice is done outside the classroom where the instructor has no input or control over the direction the student's thinking is taking.

An intermediate French class is rapidly filling classroom 106--the CAI classroom. Students enter, sit at separate consoles (terminals) and begin working on individual lessons. Each student goes through the required lessons at his/her own speed. Thus, some students have nearly finished all the lessons while others are farther behind.

Carol Fisher is working on a lesson on verb conjugations.

The material is in the form of a game, and Carol is enjoying competing against the computer. She has been through this game before, but since she's ahead in her work, she's decided to start the day with a little recreation--"playing" at conjugating verbs. Though she's a fast learner and confident about other grammatical matters, she feels she needs the extra practice at verb conjugations.

Stephen Gardner is about halfway through the total number of lessons each student has to complete. He's had trouble with translating and is working on a lesson on reading comprehension. He answers the first set of questions and the computer applauds, "Good work, Stephen! That was a tricky passage and you did very well." However, he has a little trouble with the next reading, and the computer takes him through a thorough analysis of the portions of text that gave him the most problem.

Laura Bowers is plodding along in a lesson on participles. Languages are not her forté and she's doing pretty poorly. As she works through the lesson, she requires not only a good deal of on-line remediation, but also considerable assistance from the instructor who handles any student problems or questions that arise while they're working on the terminals. Laura is aware that she gets much more individual help in this setting than in a classroom situation, and is glad of it. She figures she'd never pass this course without it.

The most obvious characteristic of CAI is that it's self-paced. Students are freed from having to keep up with or be held back by other students. If a student is having difficulty with some subject or concept, his/her comprehension doesn't have to be sacrificed to the group's "moving ahead." CAI is also individualized so that each student's

particular problems can be dealt with separately either by on-line remediation or instructor assistance. Since all students won't require the same amount of help, the instructor is freed to spend more time with those who need the most attention.

Using CAI, each student has the chance to answer (and get feedback on) each question. However, students can't learn from each others' wrong responses. Lessons can also be structured so that students are able to "practice" (again with specific feedback) until they feel confident of whatever concept they're working on. Of course, the computer can only respond to actual student input. It can't see the student, so it can't detect those bewildered looks instructors are so familiar with.

Since CAI is different from other instructional media, you will need to make some decisions BEFORE you begin to write a lesson. Some of these matters were topics you did not even have to think about in traditional instruction.

DECIDE WHY CAI IS THE BEST MEDIUM FOR THIS LESSON.

CAI is not a treatment. It is a medium. It has much to offer that is not available via traditional instructional vehicles. If used appropriately, it can be extremely effective. If used inappropriately, it may have little to offer. After you have chosen a lesson to program, stop to ask yourself why you should use CAI. You may want to generate a lot of exercises for a drill. Perhaps you want to create a dialogue situation in which the student has verbal exchanges with a simulated patient or client. You may also want to provide the student with an experience which is not feasible through another medium. Your students may vary widely in background and ability, so you may want to individualize instruction. For example, you may want to provide extra practice exercises, or more detailed explanations only for those students who need the help.

How Would CAI Be A Disadvantage For You?

Perhaps it will take too long to produce a lesson. Perhaps the material can be taught just as readily by some other means, such as a textbook or instructor. It may be that the student will need to use a reference page, and it's too hard to go back and forth between displays.

MYTH: A NEW AUTHOR CAN WRITE A LESSON WITHOUT PLANNING.

An author at a remote site had just returned home after a one-week course in coding which also included a smattering of instructional design. He felt challenged by and enthusiastic about the potential of CAI. He was eager to begin writing his own lessons. He thought writing lessons was tremendously creative and he regarded himself as a creative person.

During the short training course, staff instructors had stressed the importance of preplanning as the first step in lesson writing, with particular emphasis given to a fairly careful construction of a list of the things the author actually wanted the student to be able to do at the lesson's end. During the training course the author had seen the importance in such prior analysis, but once he got home and actually began writing his first lesson, he found prior planning rather tedious--a little like having to practice scales when you want to play Beethoven. He tried to decide what material should be included; he tried to plot out the lesson's organization. But he felt stifled, anxious to really get down to "writing" the lesson. He finally announced that he (being so highly creative) could not function this way. His "technique" would be to sit at the terminal and "create" in a rather improptu fashion--ad libbing as he went along. This procedure felt much more comfortable. And after all, he knew that other more experienced authors often "improvised." Besides, he was bursting with ideas--he had seen some fascinating games and wanted to write a game; he had seen some dazzling displays and wanted to create some graphics. So he set out, spirits high, expectations even higher. He struggled, but felt invigorated by the struggle. He labored, but felt challenged by the labor. He rhapsodized, "Writing lessons is so creative and personal--it's

like giving birth!"

Slightly over a year later, he bore a rambling, hop-scotching, patchwork of a lesson, disjointed and discordant, a blend of mayhem and mediocrity. Throughout the year most of his time had been eaten away by reworking, reshuffling and rewriting what he'd already done. New material was tacked on to the end of the lesson producing a rather, "And-oh-yes-I-forgot-to-mention..." effect. He'd constructed a "game", but the rules were so complicated no one could play it. He had included his graphics, but they were juvenile and cartoonish. The students for whom the lesson was written came to refer to it as "Sesame Street".

This author was well-intentioned, hard-working, and enthusiastic, but he was ambushed by a number of designi "myths". The first was that planning and writing a lesson are somehow separate. That's like saying playing the flute and learning what finger positions produce what notes are two different things. Naturally creativity plays an importan role in quality. Just knowing finger positions is no guarantee that a person will be able to make music (though they may make noise!). However, not knowing positions is a virtual guarantee that they won't make music.

No one, not even experienced authors, can simply sit down and write a lesson extemporaneously without some plan in mind (if not on paper) for what they want to do and what they want the student to do. While it's true that experienced authors often "compose" at the terminal, they are able to (successfully, at least!) only because they have a firm, broad springboard of experience on which to rely. Any craft

is grounded in a certain set of skills at which the craftsman must be proficient. They are the heart of the craft. The author in our scenario was misled by the outward behavior of other more experienced authors. He only saw (and believed) the fact that they were able to "ad lib" a lesson on-line. He didn't see the mental organization that had gone on or the fact that they were able to "ad lib" only because, having written a number of lessons, they had practiced and become proficient at the necessary skills. Just as one would not expect a jazz artist to improvise a piece of music without having a solid musical foundation of discipline and understanding, one could not reasonably expect that a "novice" author could improvise a lesson without a solid instructional foundation of design and media experience. As a result of his extemporizing without sufficient planning, the author wound up spending an inordinate amount of time redoing huge chunks of his lesson, dragging lesson development out much longer than was warranted.

Finally, because he had been impressed by demonstrations of some interesting games and graphics, he naturally wanted to incorporate similar techniques into his lesson. Gathering new ideas from various sources is certainly a laudable approach, but he tried to apply techniques for their own sake rather than for their educational effect. The net effect was that they were considered juvenile and inappropriate.

Therefore, the best approach (especially if you're not particularly experienced with CAI) is to plan your lessons before you begin to code them. In order to do that you will have to make a number of decisions. One of the first, concerns your goals for the student.

DECIDE ON THE GOALS OF THE LESSON.

Clearly and concisely stating what you expect of the student is one useful way of organizing the lesson material both in your own mind and in the student's mind. This technique can help you, as the author, pare away irrelevancies and stucture the material in a less rambling, more cohesive lesson. State expectations as precisely and unambiguously as possible. Look at the following examples:

Bad example: "Know the names of the parts of a truck engine."

Good example: "Match the names of the parts of a truck engine to the proper places in a diagram, with 95% accuracy."

The terms in the first example are unclear and can be easily misunderstood. What does the author mean by "know"? S/he might mean "list" the parts of an engine, or s/he could mean that given a drawing of an engine, the student will name each part. The second example, however, clearly conveys exactly what the student will have to do. Sometimes goals can not be stated so precisely, or in exact behavioral terms. But wherever it's possible, rather than asking, "What do I want the student to know," ask youself, "What do I want the student to be able to do?"

In addition to helping you organize the lesson material, stating specific expectations will help you figure out how to measure whether the student has learned what you had hoped. Without some reliable measurement of the student's post-lesson knowledge or skills, you won't know whether you've effectively gotten the material across.

DECIDE HOW YOU ARE GOING TO MEASURE STUDENT PERFORMANCE.

What Sorts Of Questions Should You Use?

The questions you choose depend on the goals you have set. For example, if your goal is for students to memorize the multiplication tables from one to nine, you may want to use some sort of drill to measure their performance. If your goal is for students to be able to apply Boyle's Law, you'll probably want to construct some new problems in which students have to use Boyle's Law. The trick is to be sure your questions really do test the skills you intend. For example, suppose the student answered the following question correctly:

Type the number of the correct answer --

The Pythagorean Theorem states that the:

1. hypotenuse 2 = the sum of the sides.
2. (sum of the sides) 2 = the hypotenuse.
3. hypotenuse 2 = the sum of the squares of the sides.
4. hypotenuse 2 = (sum of the sides) 2.

The most you can infer is that the student is able to pick out the correct answer when given a choice. You cannot, however, extrapolate that the student is also able to state the theorem or apply it in a new situation.

How Many Questions Should You Use?

At one CAI site, end-of-lesson tests consisted of one test item per concept (much to the horror of assorted CAI

consultants!). Though there really is no good rule-of-thumb for deciding on the number of items, bear in mind the difficulty of the material and the types of questions you're using. Passing or failing one item doesn't tell you a lot about the student's proficiency. On the other hand, too many items can frustrate the student.

MYTH: PRESENTING IS TEACHING (A LESSON IS CONTENT)

At a university CAI site, the director decided that all project lessons should be evaluated by outside content experts. His decision was roundly applauded by friend and foe alike as a giant step toward quality control. The revolutionary director constructed a list of guidelines for any consultant reviewing the lessons. The only problem was that the only sorts of reviewer comments the director solicited or allowed for were content questions. In fact he went so far as to specifically request that no comments be made about the workings or design of the lesson itself.

This emphasis on content alone resulted in the project's lessons evolving over a period of time into "page-turners"--heavily textual, book-like lessons with little student interaction. Because of the density of the text, students were strongly encouraged to sit at their terminals and take notes. Most did--so thoroughly, in fact, that they began to seem like modern day scribes, conscientiously transcribing little books of their own.

DECIDE WHAT APPROACH THE LESSON WILL TAKE.

The beauty of a powerful CAI system is that it enables you to choose from among many teaching styles. You can use sophisticated student/computer interaction to provide your students with experiences that are not otherwise possible. Of course, the traditional text-laced-with-questions technique is also a possibility, and many new authors begin there. The point is that many alternatives are available. You can use more than one in a lesson; you don't have to stay with a single approach throughout. Here are a few examples of what you can do.

Drills -- cycle students through a series of problems, questions, definitions, etc. Questions can be given in the same order to all students or randomly selected from a pool of items. You can also cycle students back through those items they missed for extra practice. This is a good technique for reinforcing rote memory skills such as foreign language vocabulary acquisition, spelling, multiplication tables, specialized terminology, etc. Acceptable student performance can be set at any level, depending on your goals. They can range from a specified percentage to total mastery.

Tutorials -- lead students through a socratic sort of dialogue. This is a good method for guiding students through some process or problem-solving situation. As the author, you can use tutorials to direct a student's thinking. On the other hand, students usually have very little autonomy in this situation, and can sometimes feel frustrated. Authors sometimes opt for using tutorials mainly in remedial or help-type situations (after the student has either failed some basic criterion or requested help.

Inquiries -- basically present students with a "20 Questions" situation in which the computer presents an unknown of some sort (usually chosen at random from a pool of possibilities), and students must ask questions, run tests on the unknown, etc. to determine what it is. This method has obvious applications to the hard sciences, but some imaginative authors can find applications for it in other disciplines.

Simulations -- place students in a controlled, "real-life" situation in which they must bring the situation to some sort of resolution. For example, there are many clincial simulations in which students play the role of the physician and must take a patient history, do a physical examination, request laboratory information, then tie all the information into a diagnosis of the patient's condition. There are other simulations in which students play the role of a mediator or other person in a position of authority who must settle a labor dispute, negotiate a peace agreement between warring factions, etc. There are as many possibilities as there are real-life conflicts. This method allows the student to make mistakes which might be critical in real-life, but are innocuous in the controlled environment of the simulation. It can also provide the student with a realistic situation or dilemma s/he might otherwise have only been able to learn about on a theoretical level. This is also an excellent technique to use when your goal is to bring about attitudinal changes.

There are also other sorts of simulations, however. You can put students in a simulated laboratory situation in which they perform some experiment or laboratory procedure, the advantages being that the results are both instantaneous and harmless! You can also put students in a predictive simulation in which they "plug" data into a model which then predicts likely outcomes. An example is a population dynamics

model in which the student feeds in information on birthrate, available resources, etc., and the model plots out the consequences.

Games -- put students in a situation in which they are in competition with other students, the computer, the clock, or anything else you can think of. Games may be realistic or fanciful. Games are useful in developing numerous skills, and can turn learning into entertainment.

How Much Control Should Students Have?

Students should have the option of going back to review lesson material that they have already covered. The only potential problem is that students sometimes spend so much time reviewing, they don't finish a lesson in a reasonable amount of time. Your student data (or classroom observation) will tell you whether a student is spending too much time in lessons or lagging behind in the curriculum. At that point some direct intervention may be the best course.

Going a step further, though, if the lesson material is flexible enough so that order is unimportant, consider letting students determine their own path through the lesson. Chances are that students who are unfamiliar with the subject matter will tend to go through the material in order rather than jump back and forth. However, students may find it helpful to be able to skip around if they are already familiar with the material or want to review previous sections. This can be handled a number of ways. You can provide a lesson index to which students have access from any point in the lesson. They can then go through the material in sequence or vary the order. If you want a little more control over the course students take, you can give them a series of more

limited choices after each section such as:

Now what would you like to do?
(type the letter of your choice)

a. go to the next section
b. go back to a previous section
c. go through this section again
d. take the quiz on this section.

Tracking the students' progress through the lesson becomes even more important when you allow them some autonomy. Students have been known to skip parts that are uninteresting or too difficult, so you will want to be sure that they have been through every section before they complete the lesson.

DECIDE HOW YOU WILL QUESTION THE STUDENT.

CAI is similar to a private tutor. It is interactive and it allows every student to answer every question. A private tutor asks questions periodically to find out if the student understands each section. The tutor provides hints, explanation, and other forms of remediation as the need arises. In the same way, the CAI lesson can ask questions to monitor the student's understanding and to provide additional help when the student needs it. A big difference between CAI and tutoring is that the tutor can make decisions about what to ask and how to respond as he works with the student. The author of a CAI lesson has to make many of these decisions before students try the lesson.

What Question Formats Should You Use?

There are many good sources with detailed analyses of

the pros and cons of each question form over the others (see reference list). In our present context, let us simply reiterate the need to match the type of interaction to the level of student competence you're aiming for.

Where Should You Insert Questions?

Is it good enough to wait until the end of the lesson? Emphatically, NO! That may seem to be the simplest approach, but in reality it is inefficient. If the questions at the end show that the student has failed, s/he may have to repeat the entire lesson in order to learn those parts that s/he missed. In fact, if later material depends on understanding earlier content, a student who does not learn the earlier part will be unable to get anything out of later parts of the lesson.

Questions should be asked both within the lesson and at the end. Where you put them within the lesson depends on the nature of the lesson, and the age and ability of the students. If you are presenting text, and there is a lot of reading, there is an increased tendency for the student to just read the words. Ask questions after major ideas or concepts are presented to be sure the student is alert and learning as s/he goes along. If you are teaching rules, give the student some practice to see if s/he can apply the rule.

It may be a good idea to start out by inserting questions or practice only after major ideas. After you try the lesson with students, you will find out where they need more help and you can add more practice in those sections.

DECIDE HOW TO DISPLAY THE MATERIAL.

How Much Should You Put On A Single Display?

Don't give students too much to look at at one time. If

the display is chock full of things, they may miss the most important thing, or they just may give up altogether. If you must present lots of text, do it in small chunks. Present a few lines, then ask the student to press a key to get a few more lines when s/he is ready.

How Should You Highlight Material?

The way in which material is visually presented can help or hinder the student. Sorting text visually can help the student sort the material in his/her mind, and may make it easier for him/her to recall it later on. For example, if you present a number of points in a series, numbering them and presenting them in a vertical column may make it easier for the student to remember than if you had listed them in paragraph form. Underlining, capitalizing or writing in different script can also highlight important words or ideas.

How Much Time Should Students Have To Read A Display?

People read at different rates. It is usually not wise to set a specified length of time for students to read or look at a display. Let the students themselves control the timing. For example, suppose you want to present some text and an illustrative animation. Students can't read and watch the animation at the same time. Have them press a key or indicate in some way when they are ready to look at the graphics. Sometimes the author wants to retain part of a display, but also to change part of it. Be sure to make it obvious to the students that part of the display has been changed. If you rewrite a few lines of text at the bottom of the display, and the student is still looking at the top, s/he will more than likely miss the fact that a change took place.

MYTH: THE STUDENT WILL RESPOND THE WAY YOU ANTICIPATE.

At a CAI site on a large college campus, a clinician and a programmer were writing a clinical case simulation. The case was one in a series of simulations for which the "shell" had already been programmed. The student's goal was to diagnose and treat the "patient's" condition. The model was designed so that the student could gather a complete patient history, do a physical examination and request laboratory data. It was an easy matter to plug case after case into the preprogrammed structure. The programmer had already run students on a number of other similar cases and had a fair idea of what sorts of questions or responses they were likely to make.

While going through each section together, the programmer suggested a number of plausible student responses that needed to be allowed for. The clinician balked, however, saying, "Why would they ask that? With the data they should already have, they should know it doesn't apply to this case!"

"Sometimes students are befuddled and don't know what to ask next, so they ask a standard question hoping it will turn up some clue. Besides, at this point in the simulation they may not have asked all the pertinent questions yet, and so don't realize it doesn't apply," the programmer replied.

"But they should be told what a stupid question that is!" the clinician bellowed, becoming increasingly irritated at these faceless, exasperating students.

"This is a simulation, though, an attempt to replicate real life as much as possible. In real life no one will be there to monitor or censor the questions they ask a patient. Part of the point here is for them to learn on their own in the safety of a simulated situation what's relevant and what isn't."

"But with this data I'd never ask that question!" the ever-reddening clinician retorted.

"That's because you're already a physician. You can't expect students to have that same storehouse of knowledge at this point. They wouldn't have to go to school if they did," the programmer rejoined.

"They should be told they shouldn't have asked such a dumb question, that it's irrelevant, and that they're way out on a limb. They should only ask the questions we've already allowed for!" the blustering clinician boomed.

About a week later the clinician stood at the back of a classroom smuggly surveying a group of students going through his clinical cases. A number of students were stuck and tried various responses, always with the same maddening result--"You shouldn't be asking that!" With each slap on the wrist, the students' reactions escalated from puzzlement to frustration to out-and-out anger. The normally quiet classroom began to reverberate, the sound swelling from half-whispered cursing to irritated muttering to a clamoring roar of outraged students shouting to the terminals, to themselves and to each other.

"How in the $%?!? are you supposed to learn anything around here when all you get is these $@!?*! snide remarks!?"*

"Who was the #$@!?% turkey who came up with this lunacy anyway?!?"*

"Yeah!! Who does he think he is anyway?!"

The clinician opted for a hasty, unheralded retreat.

Students aren't mindreaders. Neither are authors. Unless you become an orthodox devotee of the multiple-choice question, you will sometime have to confront the fact that when you ask people to respond in an open-ended manner, they

may not respond as you hoped or anticipated (especially in "conversational" settings like open-ended clinical simulations). Of course you will want to set a certain level of acceptability, but within that range students will probably come up with varied and surprising responses. That's just fine. Part of the reason for putting material on-line at all is to individualize -- to cater to each student's needs as specifically as possible.

A big part of your problem will be to unravel and assess the student's thinking as s/he's going through the lesson. Both you and the student need to know how s/he's doing, whether s/he's grasping the material. If s/he's having trouble, s/he needs help at that point, not after s/he's botched some end-of-lesson test. This is especially crucial if the lesson material is in some hierarchy in which concepts build upon each other. If the student is lost at some link in the chain of concepts, your job is to figure out where s/he is and help him/her get started again. The student's responses should be taken seriously. In the previous anecdote, the clinician would have done better to realize that if the student were asking seemingly irrelevant questions s/he was likely floundering around and in need of help.

A big part of your problem will be to unravel and assess the student's thinking as s/he's going through the lesson. Both you and the student need to know how s/he's doing, whether s/he's grasping the material. If s/he's having trouble, s/he needs help at that point, not after s/he's botched some end-of-lesson test. This is especially crucial if the lesson material is in some hierarchy in which concepts build upon each other. If the student is lost at some link in the chain of concepts, your job is to figure out where s/he is and help him/her get started again. The student's responses should be taken seriously. In the previous anecdote, the

clinician would have done better to realize that if the student were asking seemingly irrelevant questions s/he was likely floundering around and in need of help.

DECIDE HOW TO ALLOW FOR ALL STUDENT RESPONSES.

Sometimes students say what you want them to, but in a different way, but sometimes they say something that you didn't expect. The following question is an example of the former.

Fill in the blank.

When teaching a concept, it is important to provide examples that draw attention to its _____ attributes.

The lesson author may expect the student to answer with the same word that had been used in the text ("critical"), and program the lesson to accept only that answer as correct. However, the student may respond, correctly, with such words as "defining" or "relevant." The lesson developer must be prepared to accept all reasonable alternatives as correct responses. However, rather than trying to anticipate all possible renditions, allow for a few obvious ones, then try the lesson out with a few trial students, adding resonable responses as they come up.

The preceding scenario illustrates the second point. Even when the student's response is totally unexpected, it needs some feedback. The easiest solution is a catch-all phrase of some sort to direct the student back to <u>your</u> line of thinking (while keeping a record of student responses and inserting alternative responses later on).

Make it simple for the student to know what to do. For example, suppose the lesson provides a number of options such as going on to the next exercise, the next section, the index, or to a score sheet. Suppose, too, that the student must press a different key for each alternative. Display the information where it's easy to see, so that it is available when the student needs it. Maybe you can even provide it on a handout, or have it posted on the terminal. The objective of the lesson is to help the student learn some particular content, not to see if s/he can find his/her way around.

Make it clear just what form of the answer you expect the student to give. For example, consider the following problem.

Evaluate 1/2

a) 12 b) 2 c) .5 d)1.2

You may expect students to answer with a letter, like "c", but it is not unreasonable for them to simply type ".5". If you expect them to respond with the letter of their choice, tell them so.

Provide an adequate set of directions. Say it simply and in plain English. Try to keep the reading level at, or below, the level of course content. Be sure to include all of the information that a student at the target level will need to have. Remember, s/he does not have all of the experience or knowledge that you have, and may need to be told things that you take for granted.

DECIDE HOW TO REPLY TO STUDENT RESPONSES.

Every serious student response needs a meaningful reply.

If students answer correctly, tell them so and do a little back-patting. Think of ways to encourage students when they are doing well, but don't be indiscriminate. Getting the right answer after two or three tries is ok, but not spectacular. So match the degree of enthusiasm with the particular situation.

Responding to a student's wrong response is considerably different. When the student is correct, your reply can simply center on the quality of his/her response, but when the student is wrong, your reply needs to center on the content of his/her response. Whereas it's perfectly all right to say, "Yes, you're right," it's not usually enough to simply say, "No, you're wrong." Let's look at an example of some of the sorts of feedback you can give if the student is wrong. Suppose you ask the following question:

"Fill in the blank with the appropriate term.

Organic compounds which are used to build body tissue are called _____."

You have at least four choices of ways to respond if the student answers incorrectly. First, you can simply tell the student s/he is wrong. Since this would give the student absolutely no clue as to why s/he's wrong, it's not the best alternative. Second, you could give a syntactical hint such as, "pr_____." This might be helpful if the student were working on a crossword puzzle, but isn't very meaningful in this sort of situation. A third alternative is to provide a general, all-purpose response for all wrong answers such as, "These compounds are composed of many amino acids." This provides more elaboration and gives the student a substantial

hint. If you want to be even more attentive, however, you can look at the student's answer and respond specifically to that. For example, if the student had answered, "carbohydrates", you might reply, "Carbohydrates provide energy rather than build body tissue. The compounds we're interested in are composed of many amino acids." This tells the student why s/he's wrong and gives more information about the correct answer.

How much detail you'll want to go into will depend both on the difficulty of the material and on the questionning technique you're using. For example, in a mathematics drill it can be enough to sim-ply tell the student the right answer. If the student made a common error (such as adding rather than multiplying), you could point that out. As interactions become more complicated, the student who has responded incorrectly will need a fuller explanation either of why his/her answer is wrong or more elaborate help to arrive at the correct answer.

We've assumed here that the student has responded before any feedback is given. Sometimes, without thinking, authors give the student the correct answer even before the student gives an answer of his/her own. Feedback is most effective when the student first gives a serious (rather than nonsensical) response.

DECIDE HOW TO LET STUDENTS KNOW HOW THEY'RE DOING.

In the course of normal classroom interaction, students are able to get a sense of how well they're doing compared to their classmates. However, working alone in CAI, they have no way of getting this information. Students working in CAI have found it very useful and desirable to have status data available on request. This can include a record of the student's performance, a record of how s/he stands relative to the rest of the class, or simply information about what s/he has accomplished and what s/he has left to do.

MYTH: LESSON DEVELOPMENT IS A ONE-SHOT EFFORT.

At one fledgling CAI site, the staff (entirely composed of novice authors) disregarded consultants' warnings that lesson development was an iterative rather than a one-time-around process. Though the consultants stressed the importance of numerous trial runs before actual student runs, the authors felt that by having a couple colleagues go through their lessons they could eliminate virtually all programming or design errors. Since the authors were not yet familiar enough with the medium to recognize potential pitfalls, their comments (usually rendered on the basis of only one trip through the lesson) almost invariably focused on inconsequential bugs such as spelling or punctuation errors. Authors, however, interpreted this dearth of useful criticism as an indication that their lessons were largely free of flaws and that these cursory critiques were indeed all that was really necessary. Thus armed with their comrades blessings, the authors sallied forth, confidently unleashing their lessons on the unsuspecting students.

Within days at least one student was labeled an "attitude problem" and threatened with disciplinary action (he had complained because, after over an hour in a lesson, a programming error near the end kicked him out and jumped him back to the very beginning, requiring that he go through the entire lesson again). Authors found themselves frantically fixing errors as fast as they were reported so that students could either get out of or get into various portions of lessons. Students were maddeningly stymied by questions which left them stuck in a lesson with no idea what to respond, no clues or help, and no way to either move backward or forward within the lesson. Within 5 months there was a virtually unanimous student mutiny, with nearly all asking to be reassigned to a non-CAI class.

Nearly all creative work involves an iterative process. Writers write first, second and even third drafts before their books are published. Architects draw sketch after sketch before settling on a design for a building. Any time there are choices to be made or more than one way to go about something, the final product is a result of successive approximations, doing and redoing, trying out and scrapping, until the end result "works". A prime requisite in this process is feedback from various sources. A writer can send a book to his/her editor, or an architect can show his/her sketches to colleagues. A CAI author, though, has a peculiar problem. A book or sketch can be criticized in its entirety, the critiquer having seen <u>all</u> the finished product. A lesson however, can be so individualized that each successive person going through it may see a slightly different lesson than the previous person. Each person will, therefore, have seen <u>some</u> (not all) of the lesson. People may answer questions differently and thus get different feedback for their responses. Some people need help at certain junctures while others do not. If the student is allowed to control his/her own path through the lesson, each may take a slightly different direction. And all these variables are fraught with ambushes. Feedback to student responses may be inadequate or unclear; remediation may be incomplete or superfluous; certain sequencing may seem jumbled or disorganized. A handful of colleagues going through a lesson can't possibly pin down all the potential pitfalls. The best solution is to try the lesson out on lots of students before you give it to the students it was written for--not because you want lots of "different opinions", but because the more people who go through it, the more errors and oversights will be uncovered.

DECIDE HOW TO EVALUATE YOUR LESSON.

Sometimes an idea seems really good, but when you put it on a computer it doesn't seem to fulfill its promise. If you try out parts of the lesson rather than trying to do the whole thing at once, you can prevent having to overhaul or scrap large portions of work because some fundamental deficiencies in the lesson were not discovered until after the lesson was "finished." In the long run, the most efficient way to write a lesson is to plan right from the beginning to evaluate the lesson and revise it as you go along. This is called "formative evaluation" -- evaluation for the purpose of improving or polishing the lesson as it is being written (rather than as a whole after it's completely coded).

There are a number of questions you should be seeking to answer in evaluating your lesson. For instance,

--is the content accurate?
--are there programming errors?
--are there places where students can get stuck with no available help?
--are there questions where students answer correctly but are judged as incorrect?

There are at least three major sources for answering these questions: peer reviews, student trials, and on-line data collection. Each serves a different purpose and should really not be used as a substitute for any of the others.

Peer reviews. Colleagues can help you by checking on content accuracy. They can also give suggestions on alternate or better methods of presentation.

Student trials. One objective of student trials is to find

out whether the student can get through the lesson without your standing over his/her head and telling saying, "That's not what I meant. Here's the way you're supposed to do that." Other objectives are to locate particular problem spots or programming errors, and to identify additional prerequisite skills that may be necessary in order for the student to successfully complete the lesson.

While it's difficult to state a specific rule for how many students should go through your lesson, one clue is the number of errors or possible revisions you find with each student trial. As long as you continue to uncover important flaws, you should continue to revise and student-test the lesson again and again. Using just a few students at a time makes revision less awesome.

Always retest a lesson after you've made revisions. Sometimes revisions don't solve the problem, or in trying to fix one error an author inadvertantly creates another error.

Data collection. The computer can collect information for you on such matters as lesson completion times, incorrect responses, error rates, and general performance. These can serve as a basis for intelligent decisions about the kinds of revisions that need to be made.

Some measures of lesson quality that can be detected through on-line data are: percentage of students who pass an end-of-lesson test after going through the lesson once, percentage of students who do not complete the lesson, and the number of times students repeat the lesson.

How Do You Know The Lesson Is Ready For General Use?

When there are no programming errors, students can complete the material within an allotted time, and students are able to get through the lesson without coming to a dead end,

you can begin to think about using the lesson with "real" students.

SUMMARY CHECKLIST

Planning

-- Are performance goals clearly stated?
-- Is there an end-of-lesson test?
  - Are questions appropriate to desired performance level?
  - Are there too few or too many questions?
-- Do you have a lesson evaluation plan?

Content

-- What instructional approach(es) are you using?
  - Drill?
  - Tutorial?
  - Inquiry?
  - Simulation?
  - Game?
-- How much autonomy does the student have?
-- Are there questions throughout the lesson?
-- Is transition smooth between ideas?

Displaying Material

-- Is there too much material on the screen?
-- Are important words or ideas highlighted?
-- Does the screen ever write at two places at once?
-- Is the student allowed to read at his/her own pace?

Student Responses

-- Are directions clear?
-- Have you allowed for a variety of responses?
-- Does feedback give added help or information?
-- Do you let students know how they're doing?

Evaluating Your Lesson

-- Are there content errors?
-- Are there programming errors?
-- Can students get stuck with no available help?
-- Are students' answers ever judged as wrong when they're correct?
-- Have colleagues been through your lesson?
-- Has the lesson been pretested by trial runs?
-- Are you collecting student performance data?
-- Do you review student data frequently?

REFERENCES

Anderson, R. C. & Faust, G. W. Educational psychology. New York: Dodd Mead and Company, 1973.

Avner, R. A. How to produce ineffective CAI material. Educational Technology, August 1974, 15, (8), 26-27.

Call-Himwich, E. An assessment of lesson review as a formative evaluation tool (MTC Report No. 8). Urbana, Ill: University of Illinois, Computer-based Education Research Laboratory, 1977.

Francis, L., Goldstein, M., & Call-Himwich, E. Lesson review (MTC Report No. 3). Urbana, Ill.: University of Illinois, Computer-based Education Research Laboratory, 1975.

Gropper, G. L. Instructional strategies. Englewood Cliffs, New Jersey: Educational Technology Publications, 1974.

Gropper, G. L. Diagnosis and revision in the development of instructional materials. Englewood Cliffs, New Jersey: Educational Technology Publicaions, 1974.

Gronlund, N. E. Constructing achievement tests (2nd edition). Englewood Cliffs, New Jersey: Prentice-Hall, 1977.

Making the classroom test: A guide for teachers. Princeton, New Jersey: Educational Testing Service, 1972.

Multiple choice questions: A close look. Princeton, New Jersey: Educational Testing Service, 1963.

Steinberg, E. R. A review of student control of learning in computer-assisted instruction. Journal of Computer-Based Instructional Systems, 1977, in press.

Steinberg, E. R., Avner, R. A., Call-Himwich, E., Francis, L., Himwich, H. A., Klecka, J. A., Misselt, A. L. Critical incidents in the evolution of PLATO projects. Urbana, Ill.: University of Illinois, Computer-based Education Research Laboratory, 1977.

Weaver, T. & Francis, L. Analysis of student interaction data in computer-based education. Urbana, Ill.: University of Illinois, Computer-based Education Research Laboratory, 1977.